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SUBMISSION OF SUBSTITUTE SPECIFICATION

Sir:

Attached is a Substitute Specification and a marked-up copy of the original specification. I certify that said substitute specification contains no new matter and includes the changes indicated in the marked-up copy of the original specification.

Respectfully submitted,

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Dated: October 28. 2005

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Substitute Specification (Clean Version)

METHOD TO MANUFACTURE COMPONENTS FOR GAS TURBINES

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[0001] This application claims the priority of International Application No. PCT/DE2004/000587, filed March 23, 2004, and German Patent Document No. 103 19 495.9, filed April 30, 2003, the disclosures of which are expressly incorporated by reference herein.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] The invention relates to a method to manufacture components or semi-finished parts for gas turbines.

[0003] Modern gas turbines, in particular aircraft engines, must do justice to the highest demands with respect to reliability, power, weight, economic efficiency and service life. Over the course of years, aircraft engines were developed that met the aforementioned requirements fully and have achieved a high degree of technical perfection. The selection or development of new materials, as well as suitable fabrication processes or manufacturing methods, plays a crucial role in optimizing gas turbines, in particular aircraft engines.

[0004] The most important materials for gas turbines known from the prior art are nickel alloys, titanium alloys and high-strength steels. The high-strength steels are used mainly for shafts and gear parts. Titanium alloys are typical materials for compressor parts and nickel alloys or super alloys with a nickel basis are particularly suited for the so-called hot engine parts.

[0005] In accordance with the prior art, engine parts made of the above-mentioned materials are manufactured by casting or forging. As a rule, moving blades and guide blades for gas turbines are cast. Highly stressed disks and rings, as well as all turbine blades in the compressor area, are preferably manufactured by forging. Engine disks, which are made of the

super alloy Udimet 720 LI, can be fabricated in a suitable quality by so-called casting plus forging.

[0006] Smelting crucibles are used when casting engine parts of super alloys, whereby, according to the prior art, the smelting crucibles are manufactured of oxidic materials, preferably aluminum oxide. When casting engine components of super alloys, reactions can occur between the super alloy and the crucible material, in particular aluminum oxide. A consequence of this is that oxidic inclusions can be incorporated in the component or semi-finished part being manufactured, which can lead to premature failure of the engine part. Consequently, before further processing of the component or semi-finished part, it is important that these kinds of inclusions be reliably detected so that the component or semi-finished part manufactured by casting can be discarded if need be. However, detecting these types of oxidic inclusions in super alloys in accordance with the prior art causes considerable difficulties. Reliable detection is not possible.

[0007] Starting from this situation, the present invention is based on the objective of creating a new type of method to manufacture components or semi-finished parts for gas turbines.

[0008] In accordance with the invention, a smelting crucible that is manufactured of boron nitride is used in casting. As a result of this, oxidic inclusions in the component or semi-finished part are avoided, on the one hand, and inclusions, which are based on abrasion or wear of the boron nitride, can be detected with great reliability, on the other hand.

[0009] According to an advantageous embodiment of the invention, the component or semi-finished part is subjected to an inspection for undesired inclusions subsequent to casting. Premature failure of the components or the gas turbines can be minimized as a result.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Preferred developments of the invention are yielded from the description. Without being restricted to this, one exemplary embodiment of the invention is explained in more detail making reference to the only figure.

DETAILED DESCRIPTION OF THE DRAWINGS

[0011] The present invention concerns the manufacture or fabrication of components or semi-finished parts for gas turbines, such as aircraft engines, by casting or by casting plus forging. A so-called fine casting can also be used as a casting method.

[0012] It is within the sense of the present invention that a smelting crucible that is manufactured of boron nitride is used for casting. Accordingly, a basic idea of the present invention is not using any smelting crucibles that are based on oxidic materials, such as aluminum oxide, rather smelting crucibles that are made of boron nitride. One the one hand, the incorporation of oxidic inclusions in the component or semi-finished part is avoided as a result of this. On the other hand, inclusions that might form due to abrasion or wear of the smelting crucible or boron nitride can be securely and reliably detected.

[0013] Consequently, it is within the meaning of the present invention, on the one hand, to use a smelting crucible made of boron nitride for casting, and, on the other hand, to subject the component or semi-finished part to an inspection for undesired inclusions after casting. If these sorts of inclusions are detected, the component or semi-finished part can be discarded before further processing. The fabrication of spoiled goods can be markedly reduced as a result. In addition, premature failure of components caused by these types of undesired inclusions can be reduced.

[0014] According to the invention, in order to check the component or semi-finished part for undesired inclusions, the component or semi-finished part is subjected to an x-ray test or a neutron radiography test. If undesired boron nitride inclusions are incorporated into the component or semi-finished part made of a super alloy, the boron induces a much stronger neutron weakening as compared with all other alloy elements. Compared with nickel, boron induces neutron weakening that is approximately 100 times stronger. As a result, the inclusions are high in contrast and can be detected securely. Fig. 1 shows this especially clearly.

[0015] Thus, Fig. 1 shows the result of a neutron radiography test of a component made of nickel alloys and super alloys with a boron nitride strip applied to the component. The boron nitride grains with a size of approx. 150 μm are high in contrast and can be depicted clearly vis-à-vis the elements of the super alloys.

[0016] If the inspection of the component or semi-finished part reveals that no undesired inclusions are present, the component or semi-finished part can be subjected to a further processing method, for example a coating process. If, on the other hand, undesired inclusions are detected during the inspection, the component or semi-finished part can be discarded in time.

[0017] The method in accordance with the invention that is described above is especially preferred in manufacturing engine disks of a super alloy, such as Udimet 720 LI, whereby these types of engine disks are manufactured by casting plus forging. These types of engine disks are subject to the highest mechanical stress and it is therefore especially important to avoid inclusions in the case of engine disks and detect them securely as well as reliably.